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(71) Applicants  
Kleen Air Maintenance  
Services Limited  
(Great Britain),  
Unit 25, Airfield Road,  
Christchurch, Dorset

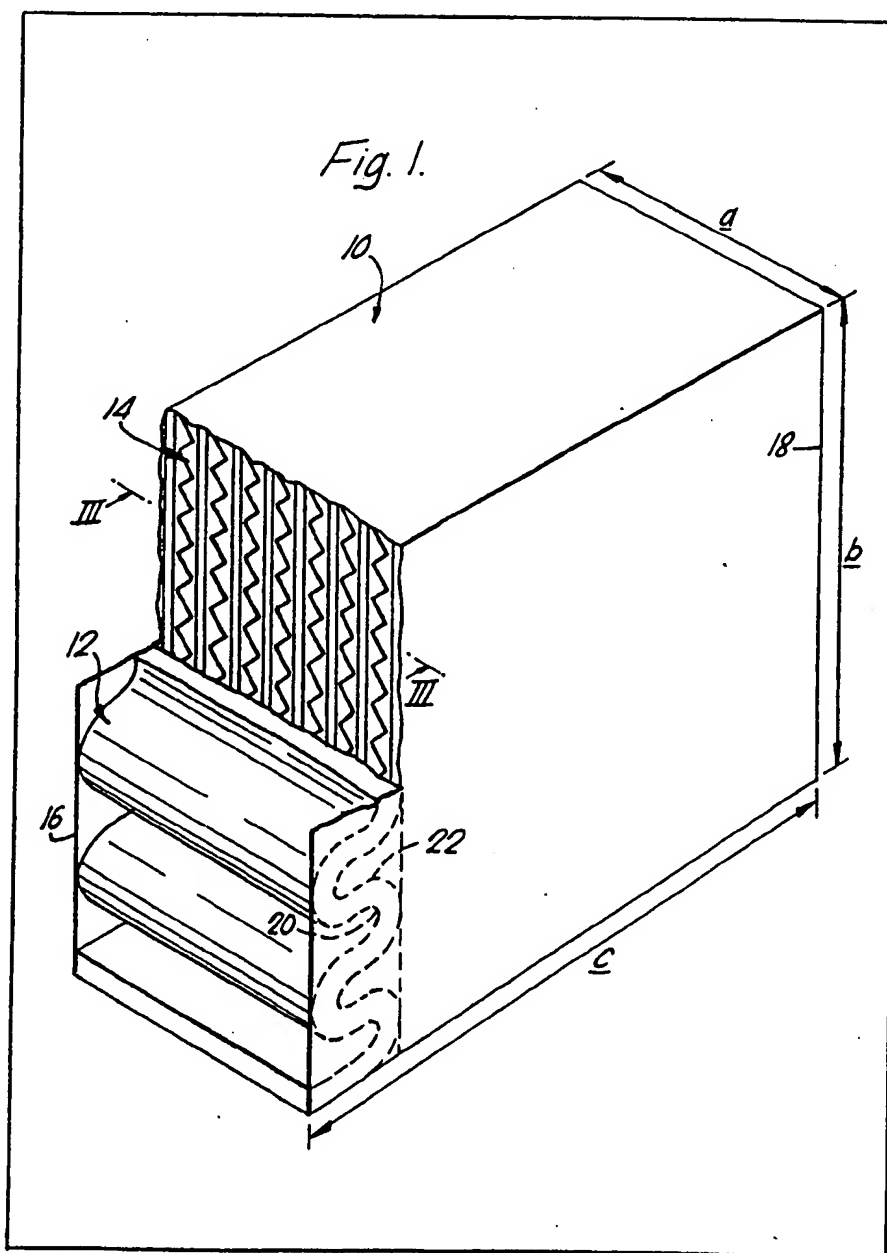
(72) Inventor  
Derek Michael  
Withrington

(74) Agents  
D. Young and Co.,  
10 Staple Inn, London  
WC1V 7RD

(54) Air filter

(57) A disposable air filter cartridge  
for an air cleaning unit comprises a  
cardboard sleeve (10) accommodating

a pre-filter (12) in the form of a  
sinuously convoluted fibrous pad to  
effect relatively coarse air filtration  
and a HEPA filter (14) to effect  
relatively fine air filtration.



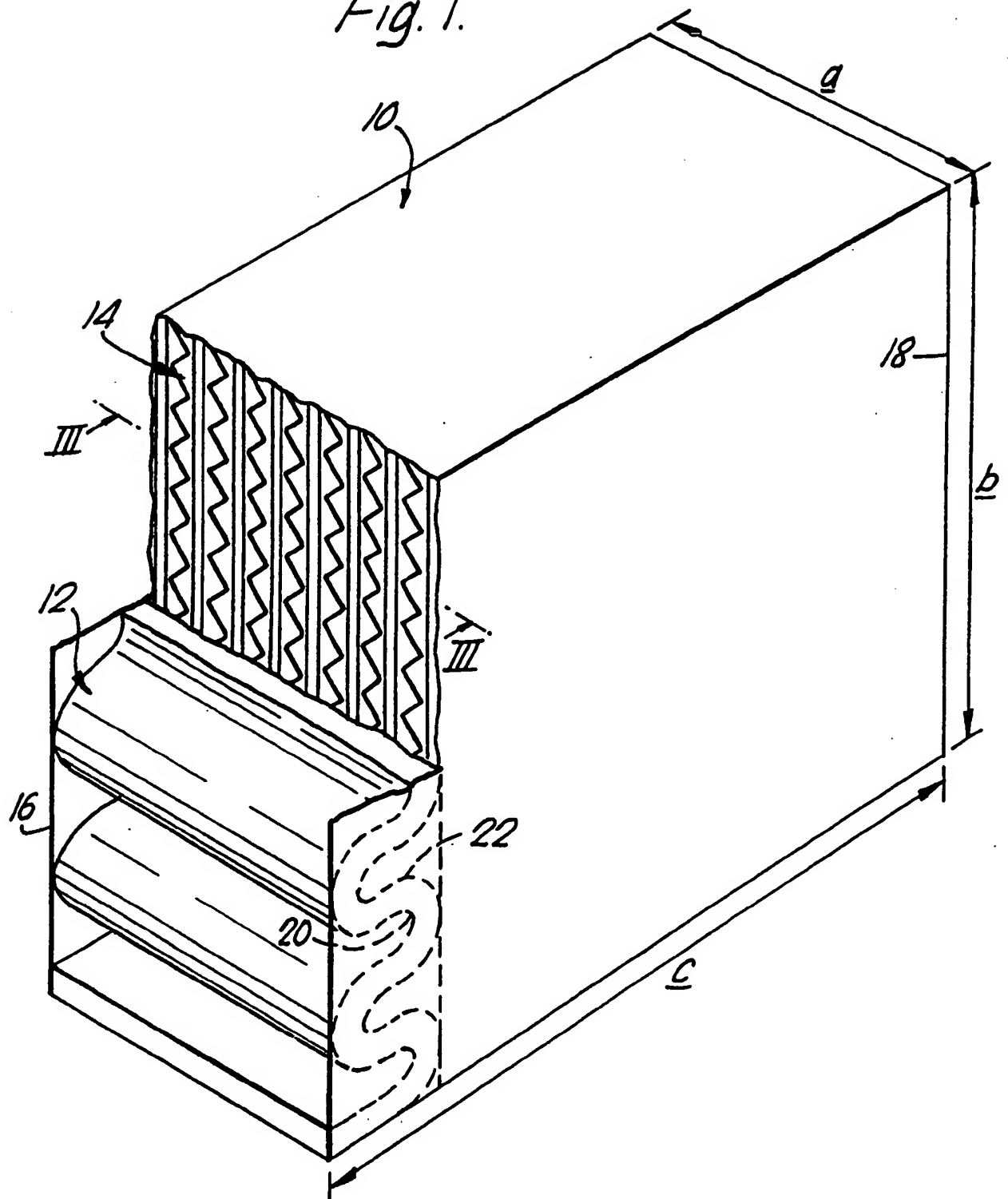
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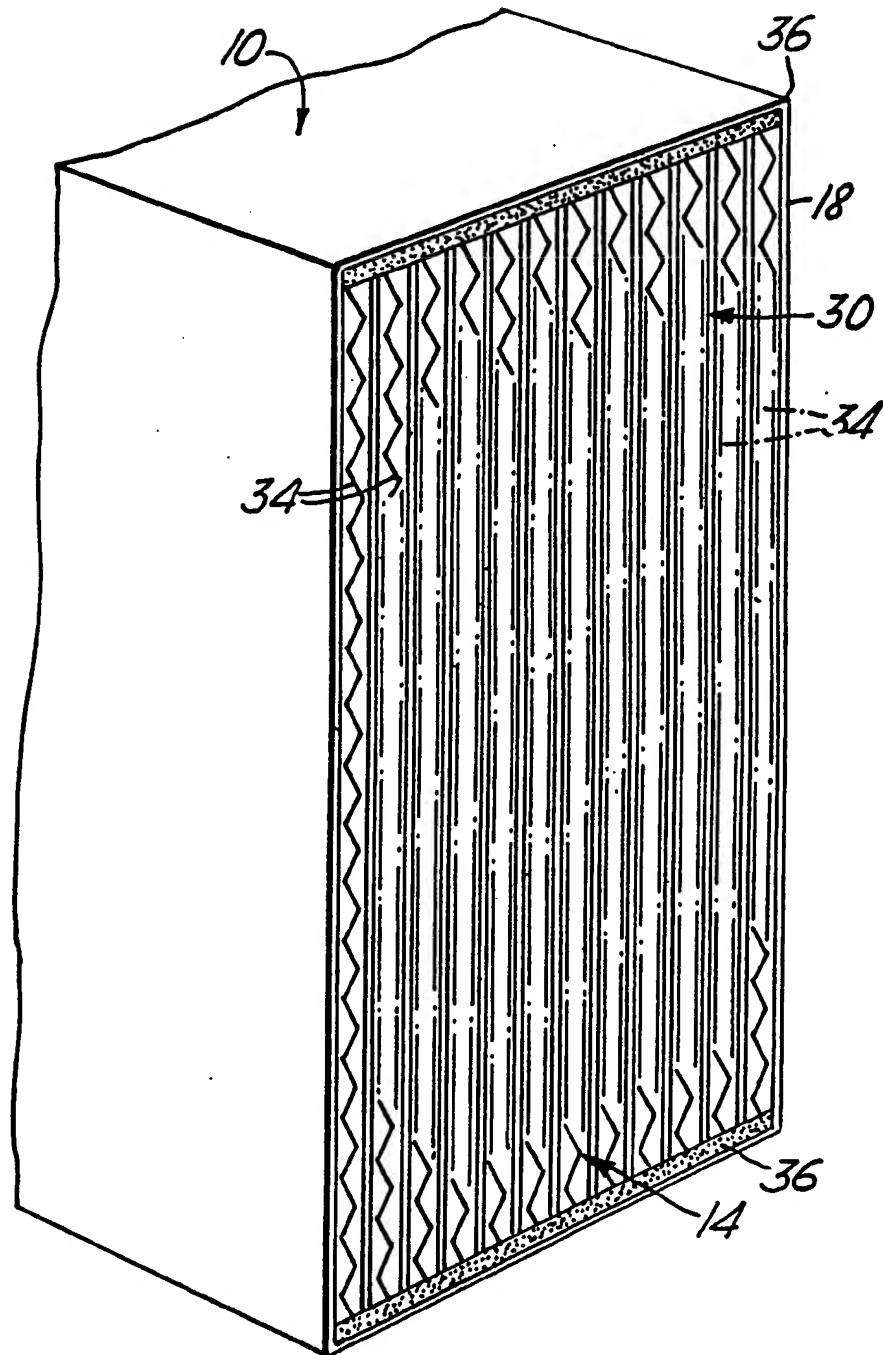
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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

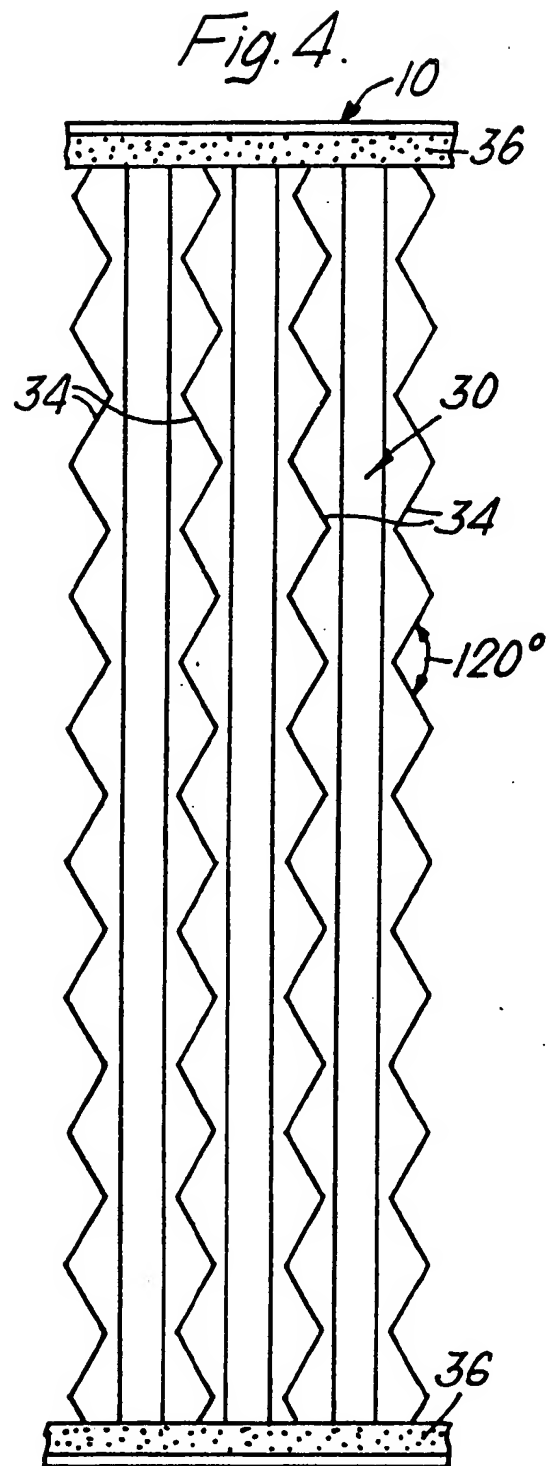
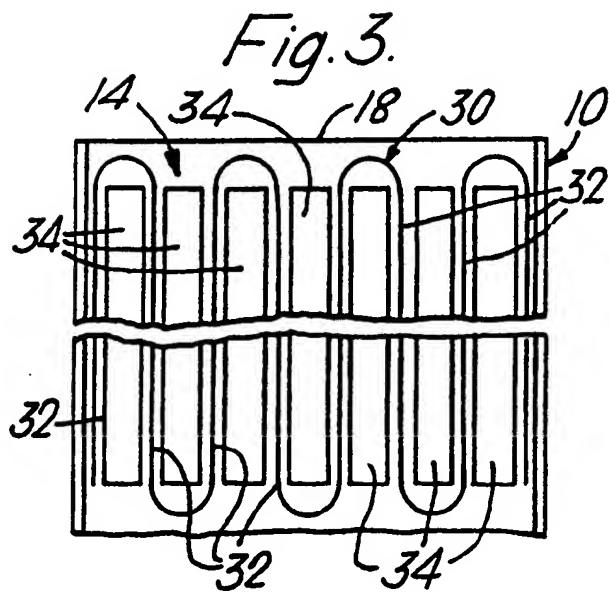
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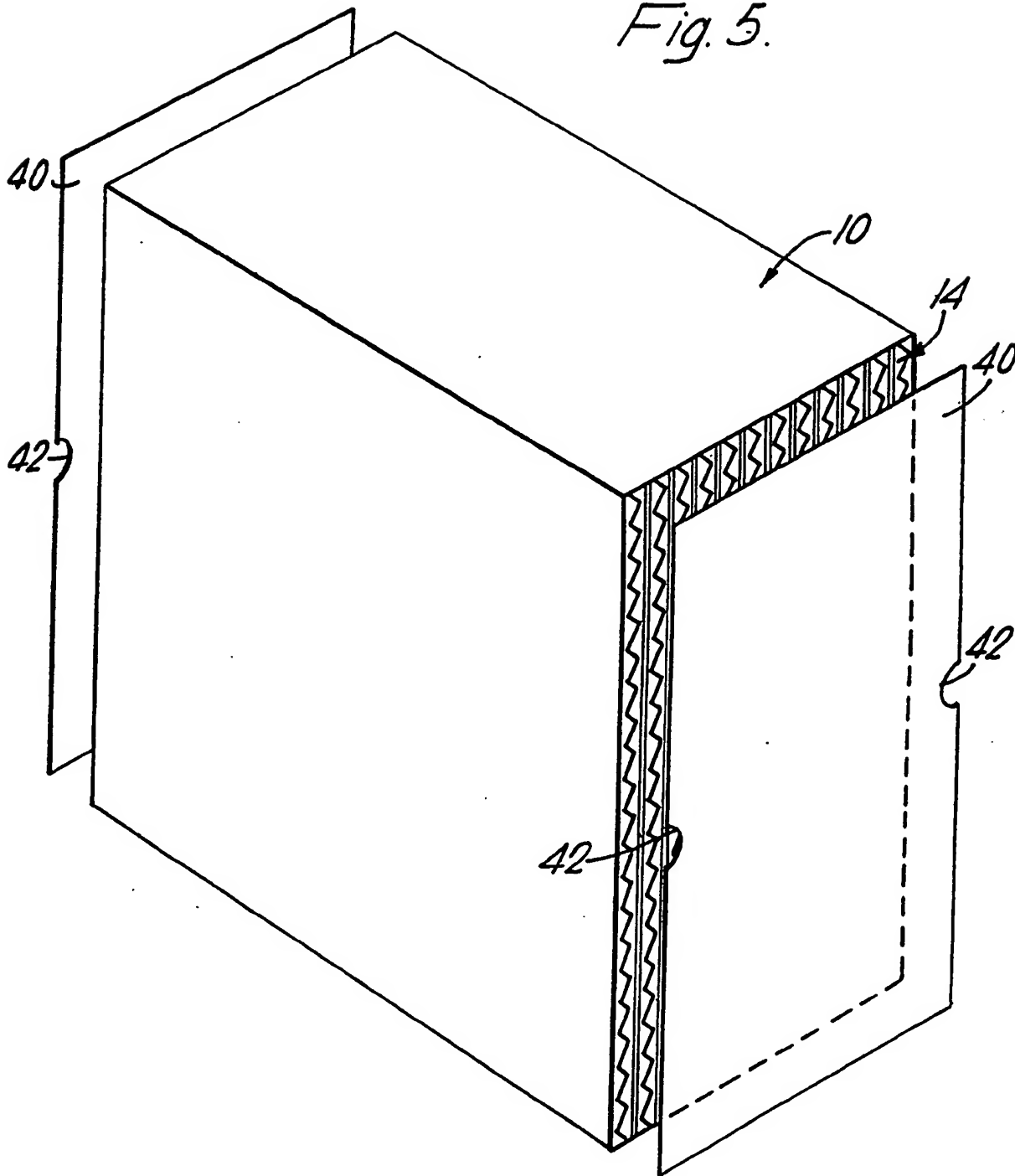
Fig. 1.



*Fig. 2.*

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*Fig. 5.*

## SPECIFICATION

## Air filter arrangements

This invention relates to air filter arrangements.

The air in bars, discos and the like tends to

5 become polluted by various substances, in particular by tobacco smoke. In the past, it was the practice to remove such pollutants by exhausting the air to the ambient atmosphere outside of the bar or disco or the like by means of  
10 a ventilation fan and/or by opening a window. A significant disadvantage of this technique is that energy that may have been expended in heating or cooling the air within the bar or the like will be largely wasted.

15 In view of the above-mentioned disadvantage, attention was directed to overcoming the problem of dirty air by cleaning the air within the bar or the like instead of exhausting it to atmosphere. One form of air cleaning means that has been  
20 employed is an electrostatic filter. Although the electrostatic filter has had some success, it is subject to a number of disadvantages. The build-up of pollutants leads to a need for frequent servicing and can alarm customers by giving rise to sporadic loud discharges. Further, electrostatic  
25 filters are not particularly effective in filtering tobacco smoke, typically removing only around 40% of the smoke particles in smoke laden air passing once through the filter. Other  
30 disadvantages comprise the production of oxone, now recognised as a health hazard, and the production of ionised air.

One form of filter designed for cleaning air is known as a HEPA (High Efficiency Particulate Air)  
35 filter. A HEPA filter, as the expression is used herein, means a filter that comprises glass microfibre filter material (e.g. in the form of one or more sheets thereof) capable of stopping the passage of very small particles.

40 The minimum size of particle that can be stopped depends upon the grade of the material. However, HEPA filters can readily be designed to stop the passage of sub-micronic particles (particles of size smaller than one micron), for  
45 instance particles of the size smaller than 0.3 microns and which therefore can be considered sub-microscopic in that they are sufficiently small that they are not in practice readily viewable by means of an optical microscope but can only  
50 readily be viewed via an electron microscope. Such filters can therefore stop tobacco smoke, the particle size of which is in general of the order of 0.3 microns. It is in fact believed possible to construct HEPA filters which will even stop some  
55 viruses. HEPA filters are believed to work by a 'microentanglement' process. The filter material comprises a maze of the microfibrils, which may be sub-micronic fibres (smaller than one micron in diameter or mean diameter) and will generally be  
60 sub-microscopic fibres (smaller than 0.3 microns in diameter or mean diameter). As contaminated air enters the maze it is forced to change direction so many times during its passage through the material that particles in the air simply drop out

65 and become entangled in the maze. Since there are no pores to block, the useful life of the material is long.

HEPA filters are essentially 'high technology' filters. They were developed for the US space  
70 programme to provide very clean air for the assembly of space vehicles. They have also been used in other applications where ultra-clean air is required, for instance in bacterial/viral filters for operating theatres. Thus, at least until recently,  
75 the HEPA filter was very expensive and was used in applications where its cost of manufacture was of secondary importance to its filtration efficiency.

Recently, the applicants managed to design a HEPA filter which could be made sufficiently  
80 cheaply to make it commercially viable for use in an air cleaning unit for use in bars, discos and the like to remove various atmospheric pollutants, in particular tobacco smoke. The air cleaning unit comprised a HEPA filter and, separate therefrom, a  
85 pre-filter. The use of a HEPA filter in this application represented a significant step forward in that it provided efficient air cleaning without being subject to the above-mentioned disadvantages of the typical electrostatic filter.  
90 However, since HEPA filters are generally expensive, by virtue of the expensive filter material employed and the constructional techniques usually necessary to make them, there is a need in air cleaning units of this kind to make the overall  
95 filtration arrangement as cheaply as possible to minimise the cost of replacement when the arrangement can no longer be used. Scope also exists for reducing the overall size of the filtration arrangement because there is a natural resistance  
100 on the part of proprietors or managers of bars or the like to the use of air cleaning means of obtrusively large size.

According to the present invention there is provided an air filter arrangement comprising a  
105 pre-filter in the form of a fibrous pad operative to effect relatively coarse filtration of air flowing therethrough and a HEPA filter operative to effect relatively fine filtration of air flowing therethrough, wherein the pre-filter and HEPA filter are both  
110 mounted within a sleeve thereby to constitute a unitary disposable air filter assembly.

According to a preferred embodiment of the invention described hereinbelow, the air filter assembly is in the form of a compact cartridge  
115 which can be inserted into an air cleaning unit which is fixed, for example to a wall, in a bar whose air is to be cleaned. The cartridge provides all the necessary filtration, the cleaning unit essentially further comprising only air movement means operative to force air through the cartridge.  
120 The construction of the cartridge is such as to minimise the cost of its manufacture and to render it readily disposable as a unit when it is replaced, typically after about 6 months or so of use.  
125 Servicing of the cleaning unit containing the cartridge is therefore very simple in that it substantially or mainly comprises only the replacement of a unitary filter cartridge.

In the above-mentioned preferred embodiment,

the fibrous pad forming the pre-filter is convoluted into parallel folds, thereby to reduce the space it occupies, and is sealingly fitted in one end of the sleeve. The pad is preferably formed from glass fibres whose density increases in the direction from an air inlet face to an outlet face of the pad; and is preferably uncompressed.

Further, in the preferred embodiment, the HEPA filter comprises a web of the glass microfibre filter material laid in a meandering or 'fanfold' fashion, with adjacent legs lying in parallel planes, the legs being held spaced apart by corrugated spacers disposed between adjacent legs. The spacers are preferably angularly corrugated, more preferably at an angle of 120° or thereabouts. The spacers may be of unglazed Kraft paper. The filter is sealingly mounted in the sleeve by adhesively securing the two outermost legs to the inside of the sleeve and by sealing the filter at its other two sides by means of strips of sealant (e.g. mastic) applied between the filter and the sleeve at least at one end of the filter.

The sleeve is preferably of a cheap material which is reasonably rigid and yet which readily permits destruction of the filter when it is to be disposed of. Cardboard, for example corrugated cardboard, is a particularly suitable material. To enhance rigidity during transit to a use location the filter arrangement may be provided with removable stiffening panels which can be inserted into respective ends of the sleeve and removed manually before installation of the arrangement.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective cutaway view from an air inlet end thereof of a unitary disposable air filter cartridge embodying the invention;

Figure 2 is a partial perspective view of the cartridge from an air outlet end thereof;

Figure 3 is a largely schematic cross section view of a HEPA filter of the cartridge taken along the line III—III in Figure 1;

Figure 4 shows in more detail a portion of the outlet end of the cartridge shown in Figure 2; and

Figure 5 is an exploded perspective view of the cartridge and two removable end stiffening panels.

The illustrated unitary disposable air filter cartridge comprises a corrugated cardboard sleeve 10 housing therein a pre-filter 12 and a HEPA filter 14. The sleeve 10 is rectangular in transverse cross section and the dimensions thereof represented by the references *a*, *b* and *c* in Figure 1 are typically equal to 21.6 cm, 40.6 cm and 44.5 cm, respectively. In use, the cartridge is disposed in an air cleaner operative to drive air through the sleeve 10 in such a direction that the air enters the sleeve 10 at an end 16 thereof nearer the pre-filter 12 and emerges at the other end 18. The cartridge is installed merely by opening a door of the unit, positioning the cartridge with the end 10 adjacent an air inlet of the unit, and closing the door.

In use, the pre-filter 12 effects a relatively

coarse filtration of air passing through the cartridge by removing grease, hair, lint, coarser dust particles and so forth. The HEPA filter 14 removes finer particles, in particular pollen, smaller lung damaging dust particles, bacteria and tobacco smoke particles. In practice, with a filter cartridge described in more detail below, it has been found that about 95% of the smoke particles in smoke-laden air can be removed in a single pass through the cartridge.

The pre-filter 12 comprises a pad of glass fibres. The density of the fibres increases from an inlet face 20 to an outlet face 22 of the pad thereby to provide a graduated increase in filtration in the direction of air flow through the pad. A suitable form of material for forming the pad is available in bulk roll form from Vokes Air Filters Limited of Burnley, Lancashire, England, a suitable grade being DS 7846/3/DRY VG. The material as supplied is intended for use as a grease filter and is intended to be compressed within a frame. In the present application it has been found preferable for the material not to be compressed.

The pad of fibrous material to form the pre-filter 12 is cut from the bulk roll material so as to have a thickness equal to the dimension *a* of the sleeve 10 but a length considerably longer than the dimension *b* of the sleeve 10. The pad is then sinuously convoluted and fitted within the inlet end 16 of the sleeve 10 as shown in Figure 1. The pad is adhesively secured (e.g. by a latex adhesive) within the sleeve 10 along both convoluted sides and along both of its opposite ends. The adhesive not only serves to fix the pre-filter in place within the sleeve 10 but also seals it within the sleeve 10 to prevent air bypassing the pre-filter 12 by travelling around its edges.

The use of a pre-filter 12 of graduated density across its width offers a greater dust absorption capacity, and leaving it in its normal expanded state, rather than compressing it within a frame, makes more use of this capacity. Convoluting the pre-filter and sealing it into the end of the filter considerably reduces its size. The use of a cheap disposable glass fibre filtration material considerably reduces production costs.

The HEPA filter 14 is formed from a web 30 of a high efficiency glass microfibre filter paper obtainable from Evans Adlard & Co Limited of Postlip Mills, Winchcombe, Cheltenham, Gloucestershire, England. The material is obtainable in various grades and various of these are suitable. One particularly suitable grade is that known as F 47W. As can best be seen from the somewhat schematic representation in Figure 3, the web 30 is laid in a meandering or fan-fold fashion, so as to have adjacent legs 32 lying in planes which are parallel to each other and to the direction of air flow. Adjacent legs 32 are held spaced apart by spacers 34, constituted by angularly corrugated sheets of Kraft paper. To reduce size and cost, unglazed pure Kraft paper is used, a typically suitable weight being 125 g/m<sup>2</sup>. In this connection, it would be usual in a HEPA

filter to use Kraft paper which is highly glazed on both sides. In the present application, it has been possible to reduce costs by using unglazed Kraft paper since the air flow and wet strength

5 requirements in the present application are not sufficiently highly stringent to require the use of the more expensive glazed Kraft paper. Further, as can best be seen from Figure 4, the paper constituting the spacer 34 is crimped or angularly  
10 corrugated at an angle of 120° rather than the more usual angle of 90°. Using a larger angle in this way enables many more of the legs 32 to be folded into a space of the same size, thereby to greatly compact and reduce the filter's size.

15 The outer faces of the two outermost legs 32 of the web 30 (i.e. the legs on the extreme right and extreme left in Figure 3) are secured to opposite faces of the inside of the sleeve 10 by a latex adhesive. This not only holds the HEPA  
20 filter 14 in place within the sleeve 10 but provides sealing against the passage of air around two of its opposite sides. The passage of air between the other two opposite sides are of the HEPA filter 14 and the sleeve 10 is prevented by the application  
25 of strips of mastic sealant 36 at the outlet end 18 of the sleeve 10 where shown in Figures 2 and 4. Like strips (not shown) of mastic sealant can be provided at the other end of the filter 14. Thus, the edges of the filter are sealed only at the inlet and  
30 exhaust ends, using a mastic sealant, whereby expensive Urethane type sealants are not necessary in this application. Neither are costly filtration efficiency testing procedures.

The above-described air filtration cartridge as  
35 will be appreciated from the foregoing, is compact and relatively inexpensive and can provide a high standard of air filtration in a variety of applications, an important one of which is the filtration of tobacco smoke in bars, discos and the like.

40 As shown in Figure 5, the cartridge may be provided with removable transit panels 40, for example of cardboard, which fit into the opposite ends of the sleeve 10 to rigidify and protect the cartridge during storage and, more particularly,  
45 during transit to a use location. The panels 40 are removed before use by the use of 'fingerhole' cut outs 32.

#### CLAIMS

50 1. An air filter arrangement comprising a pre-filter in the form of a fibrous pad operative to effect relatively coarse filtration of air flowing therethrough and a HEPA filter operative to effect relatively fine filtration of air that has passed through the pre-filter.

55 2. An air filter arrangement according to claim 1, wherein the pre-filter and HEPA filter are both mounted within a sleeve thereby to constitute a unitary disposable air filter assembly.

60 3. An air filter arrangement according to claim 2, wherein the sleeve is of cardboard.

4. An air filter arrangement according to claim 3, wherein the sleeve is of corrugated cardboard.

5. An air filter arrangement according to claim 2, claim 3 or claim 4, comprising removable

65 stiffening panels which can be inserted into respective ends of the sleeve and removed manually before installation of the arrangement.

6. An air filter arrangement according to any one of claims 2 to 5, wherein the pad is sealingly  
70 fitted in one end of the sleeve.

7. An air filter arrangement according to any one of the preceding claims, wherein the fibrous pad forming the pre-filter is convoluted into parallel folds.

75 8. An air filter arrangement according to any one of the preceding claims, wherein the pad is formed from glass fibres whose density increases in the direction from an air inlet face to an outlet face of the pad.

80 9. An air filter arrangement according to claim 8, wherein the pad is uncompressed.

10. An air filter arrangement according to any one of the preceding claims, wherein the HEPA filter comprises a web of glass microfibre filter  
85 material laid in a meandering or 'fan-fold' fashion with adjacent legs lying in parallel planes.

11. An air filter arrangement according to claim 10, wherein the legs are held spaced apart by corrugated spacers disposed between adjacent  
90 legs.

12. An air filter arrangement according to claim 11, wherein the spacers are angularly corrugated.

13. An air filter arrangement according to claim 12, wherein the spacers are angularly corrugated  
95 at an angle of 120° or thereabouts.

14. An air filter arrangement according to claim 11, claim 12 or claim 13, wherein the spacers are of unglazed Kraft paper.

15. An air filter arrangement according to any one of claims 10 to 14, when appendant to claim 2, wherein the HEPA filter is sealingly mounted in the sleeve, the sealing being effected by adhesively securing the two outermost legs to the inside of the sleeve and by sealing the filter at its  
105 other two sides by means of strips of sealant applied between the filter and the sleeve at least at one end of the filter.

16. An air filter arrangement substantially as herein described with reference to the  
110 accompanying drawings.

17. An air cleaning unit comprising an air filter arrangement according to any of the preceding claims removably accommodated therein, and air movement means operative to move air through  
115 the arrangement.

New claims or amendments to claims filed on 20 September 1982

Superseded claims 1, 2, 10, 11

120 New or amended claim:— 1; other claims renumbered, and appendancies correspondingly amended.

1. An air filter arrangement comprising a pre-filter in the form of a fibrous pad operative to effect relatively coarse filtration of air flowing  
125 therethrough, a HEPA filter operative to effect relatively fine filtration of air that has passed through the pre-filter, the HEPA filter comprising a



web of glass microfibre filter material laid in a meandering or "fan-fold" fashion with adjacent legs lying in substantially parallel planes and held

5 spaced apart by corrugated spacers, and a sleeve in which both filters are mounted thereby to constitute a unitary disposable air filter assembly.

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